

High Efficient and Wideband Linear PA Design for 5G mm-wave Communications

Junlei Zhao, Alireza Shamsafar, Mohadig Rousstia, Sergio Pires
Ampleon, Netherlands

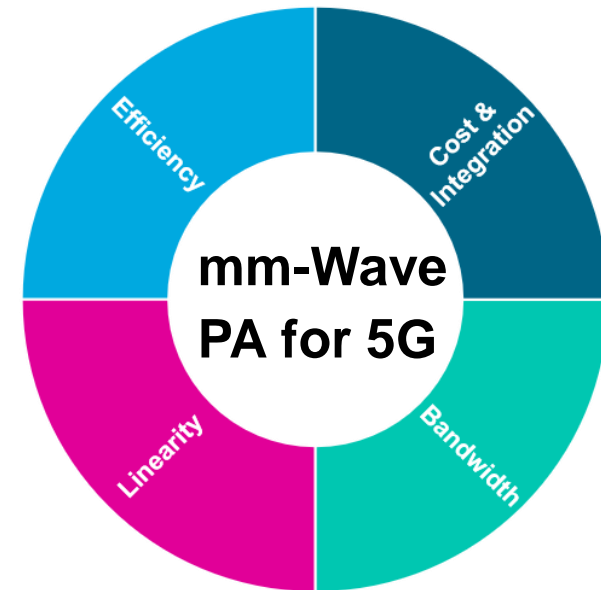
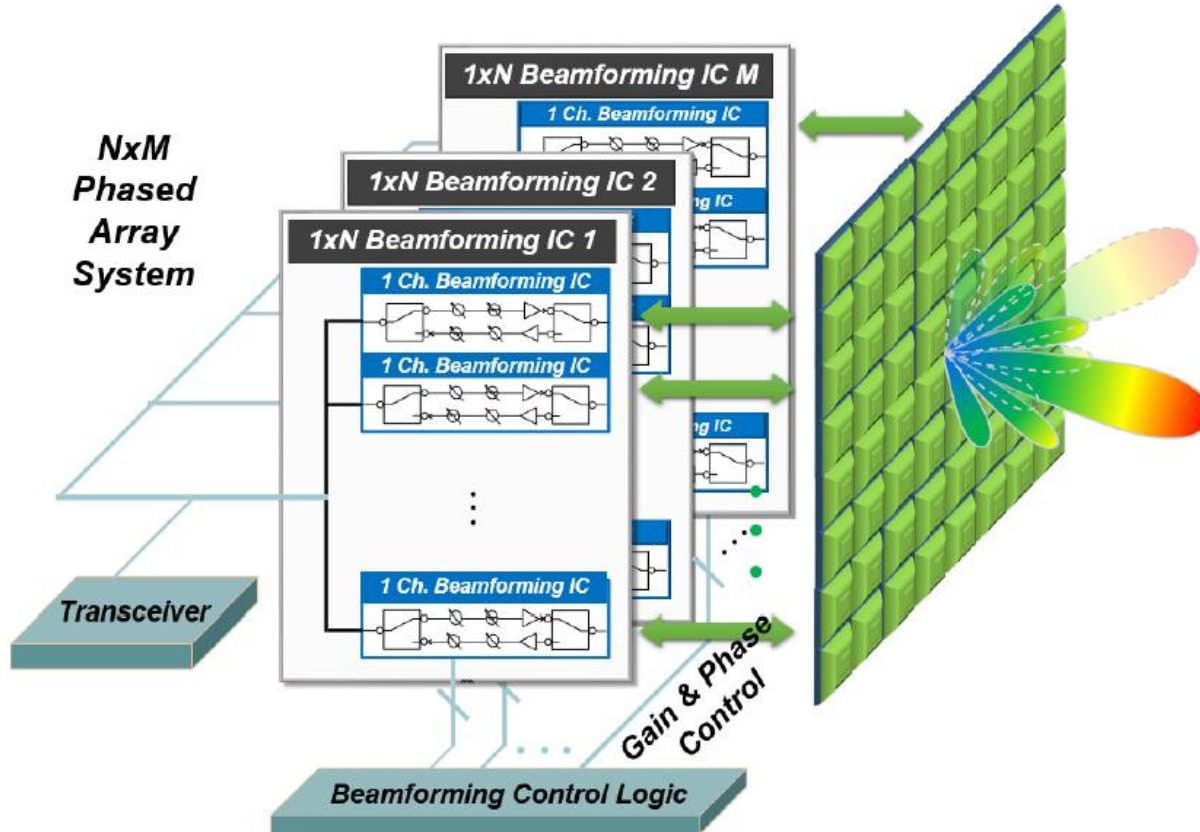
5G Era Is Really Coming

- 2019 is the start of commercial 5G



[“http://www.emfexplained.info/?ID=25916”](http://www.emfexplained.info/?ID=25916)

Mm-Wave PA for 5G



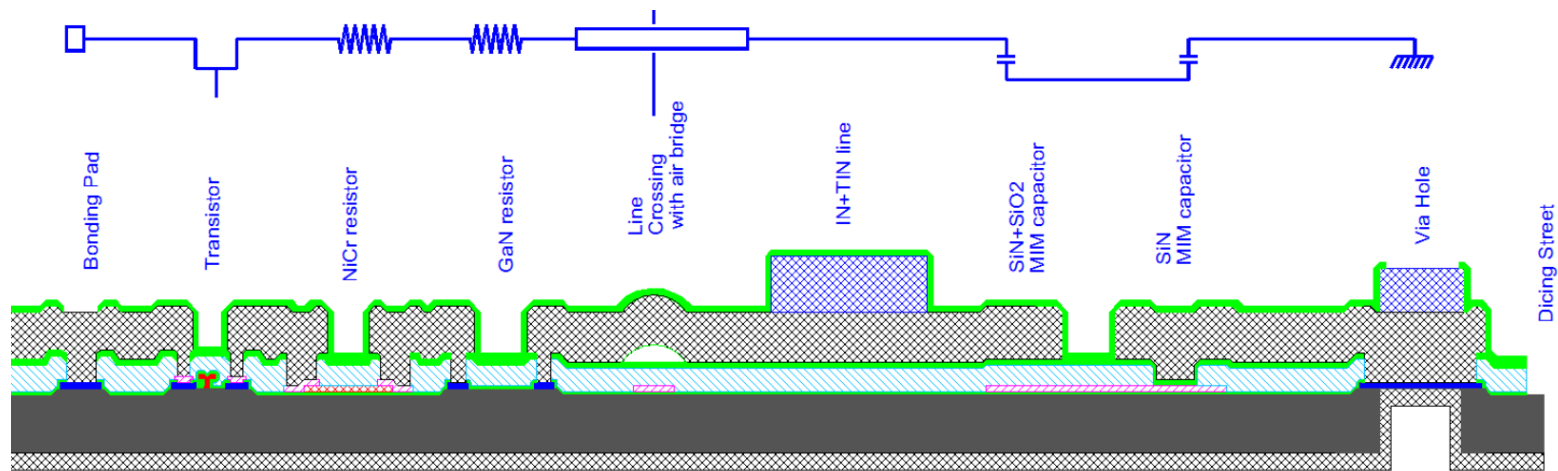
“ISSCC2019-09_Visuals”

System Analysis

- Target 70dBm EIRP
 - 128 antennas, antenna unit gain 5dBi, 1 antenna/PA
 - TX cell $OP_{avg} = 70 - 5 - 10 \cdot \log(128) - 10 \cdot \log(128) = 23\text{dBm}$
 - PA cell $OP_{avg} = 23 + 2 = 25\text{dBm}$, assuming 2dB SW IL
 - PA cell $OP_{peak} = 25 + 10 = 35\text{dBm}$, assuming 10dB PAPR
- Gain of PA is critical
 - Silicon beamforming core has limited $OP_{1dB} < 20\text{dBm}$
 - $\text{Gain} > OP_{peak} - 15 = 20\text{dB}$

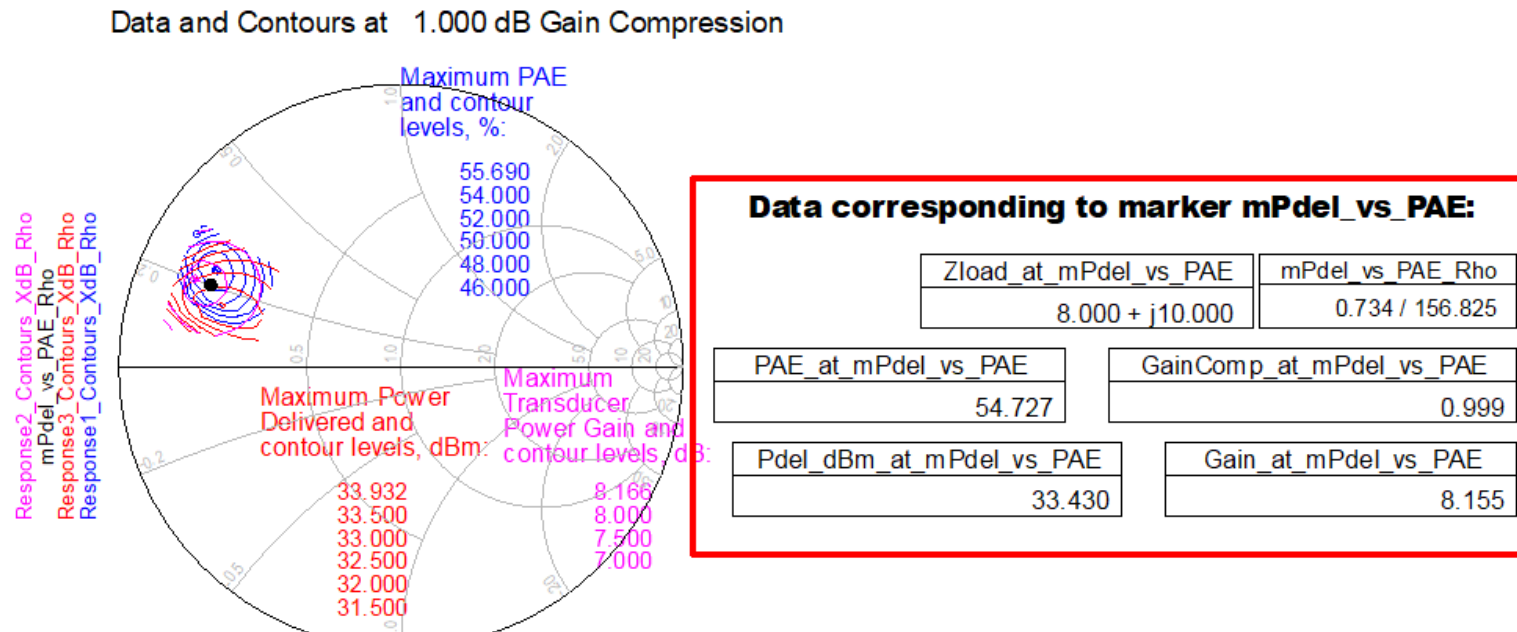
GaN Technology

- 100nm GaN/Si
- $F_t = 105\text{GHz}$
- Power density: 3W/mm, 12V supply



Device Selection

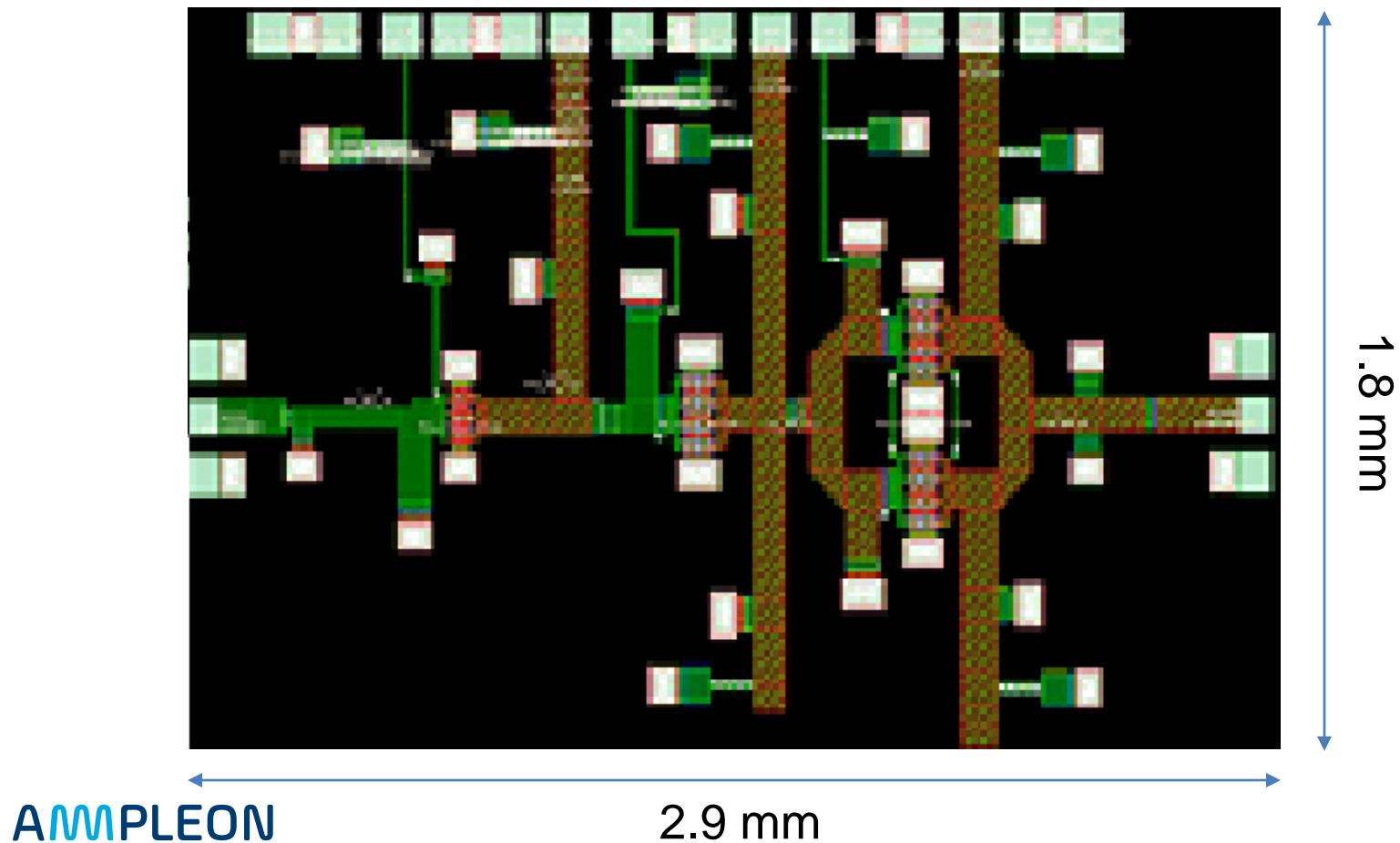
- Trade-off between power and gain



Loadpull result of a device 8x70um

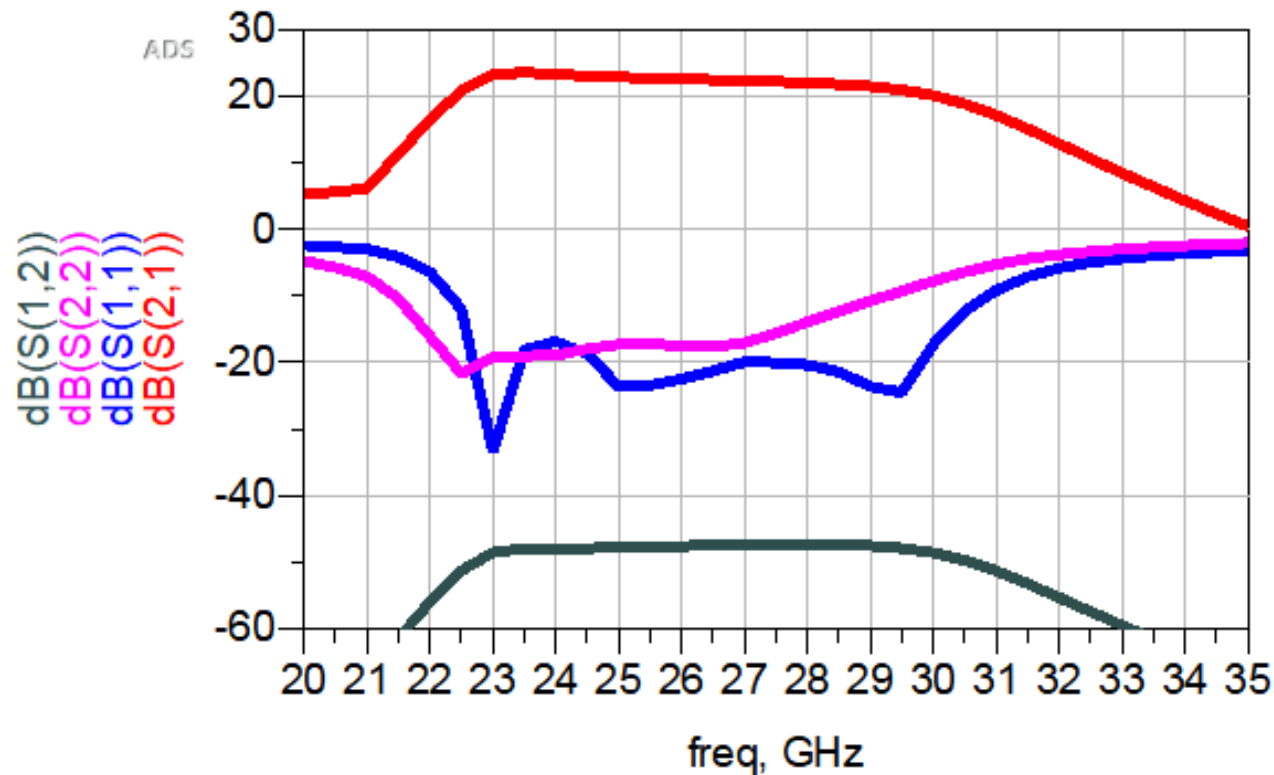
PA Layout

- 3-stage for $>20\text{dB}$ gain



Simulated S-parameters

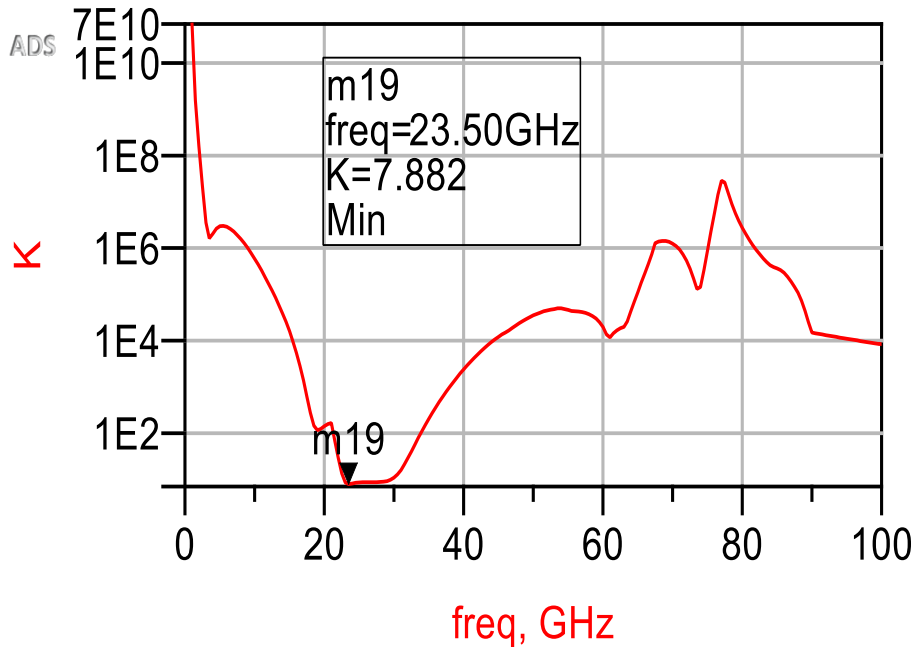
- Wideband performance: 23-30GHz



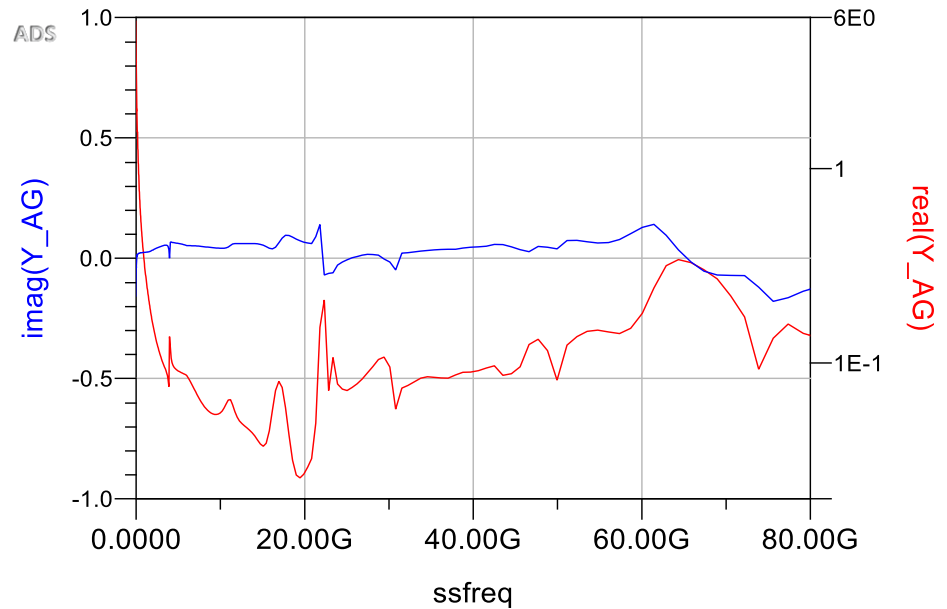
Stability

- Both small signal and large signal (STAN)

Stability Factor, K (should be >1)

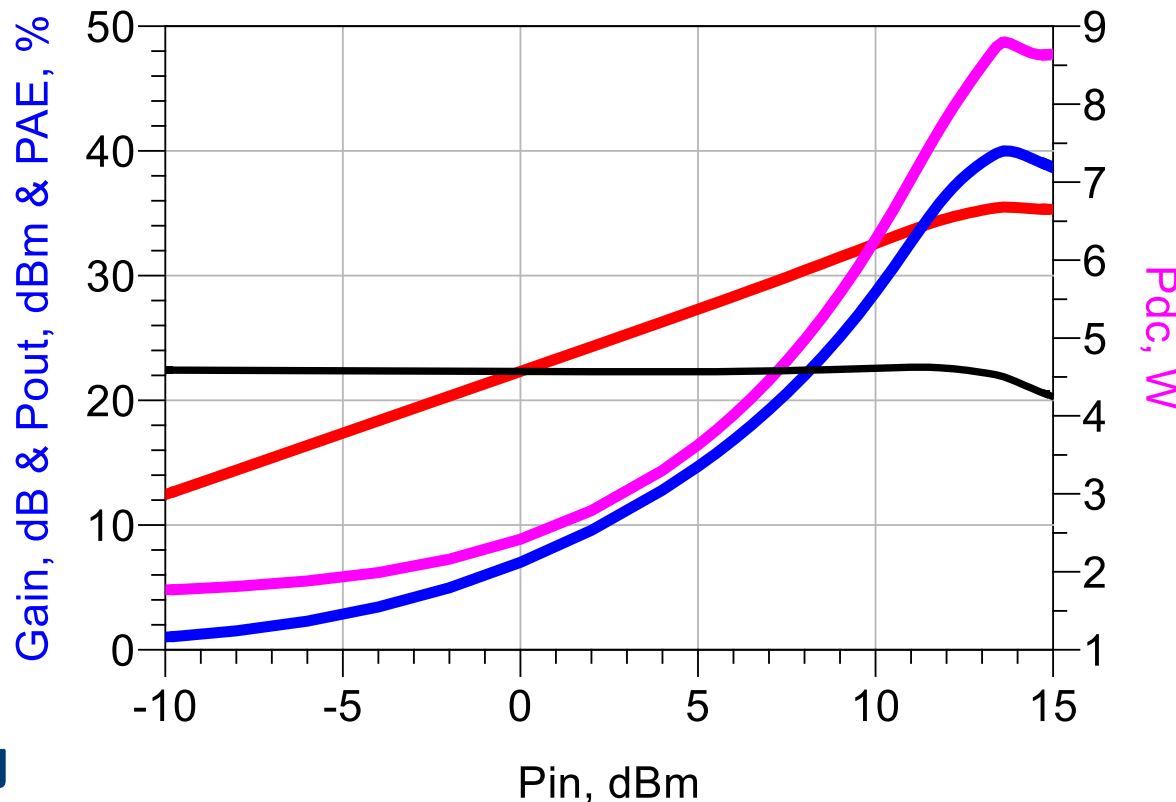


Admittance Seen by Auxiliary Generator



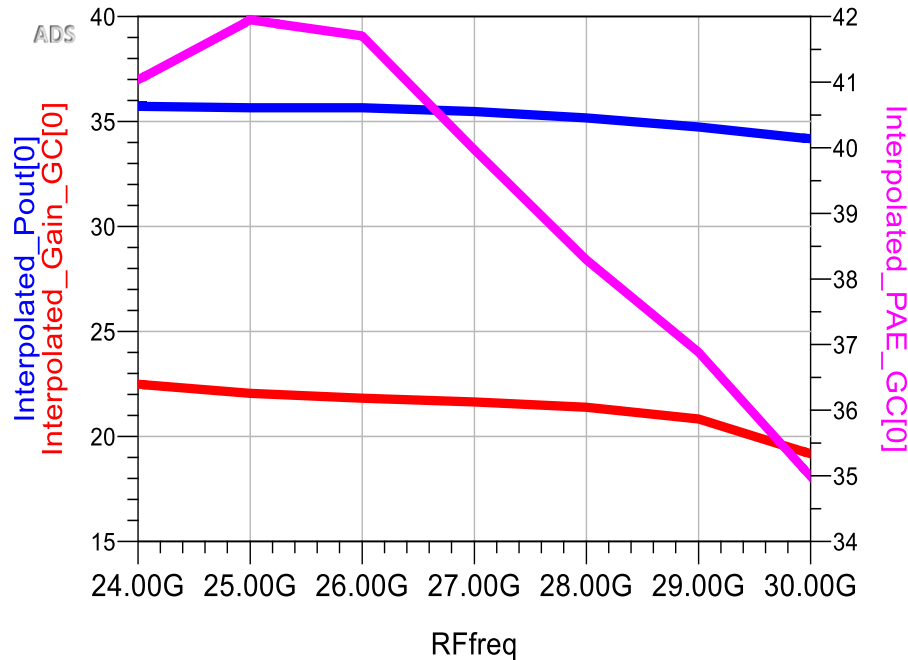
1-tone Performance @27GHz

- 35.5dBm OP1dB and 40% PAE1dB @27GHz
- Pdc decreases to 1/3 at 10dB back-off

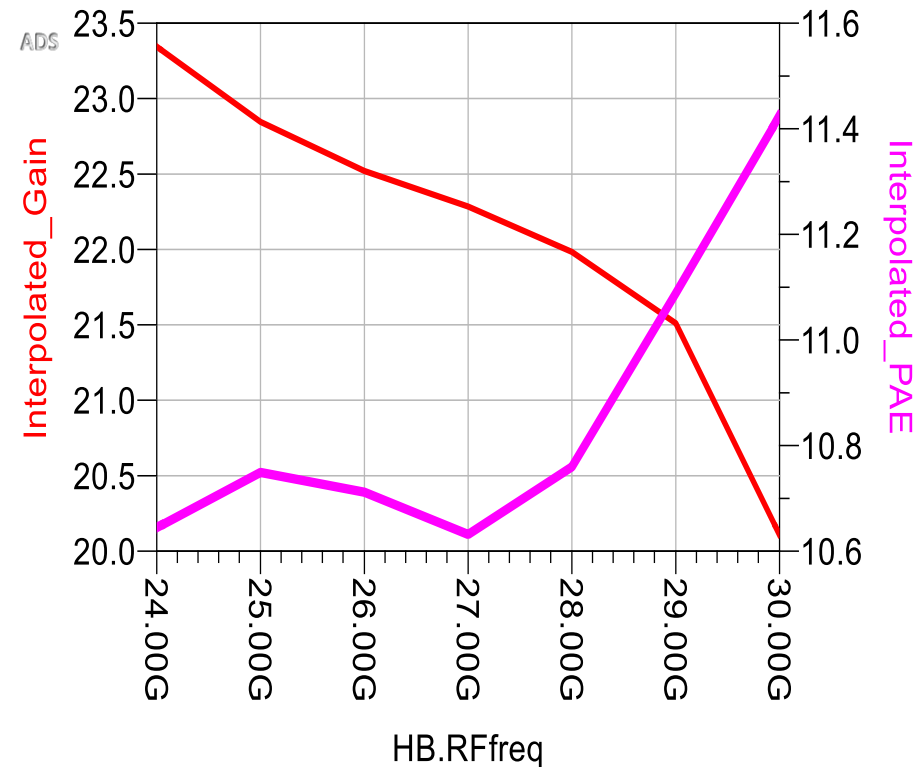


1-tone Performance over 24-30GHz

@1dB compression

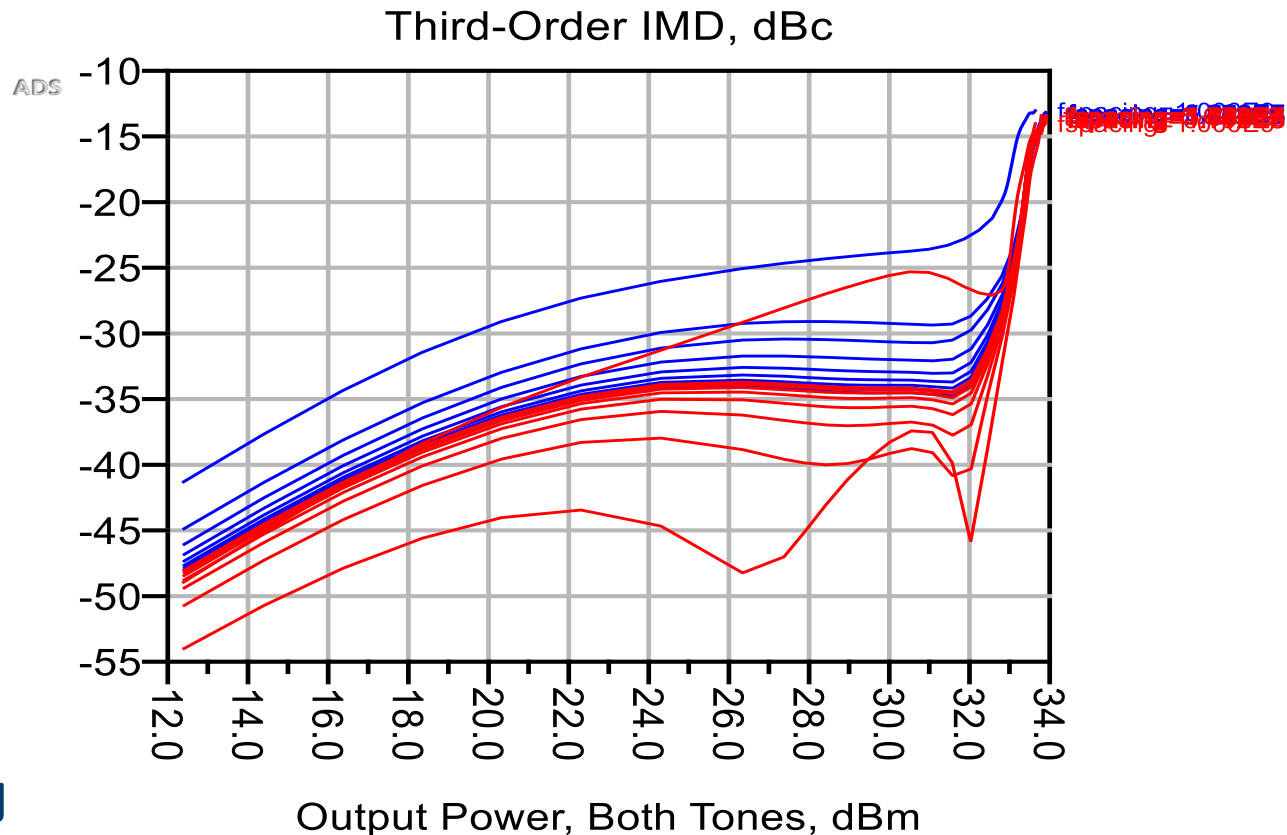


@25dBm Pout



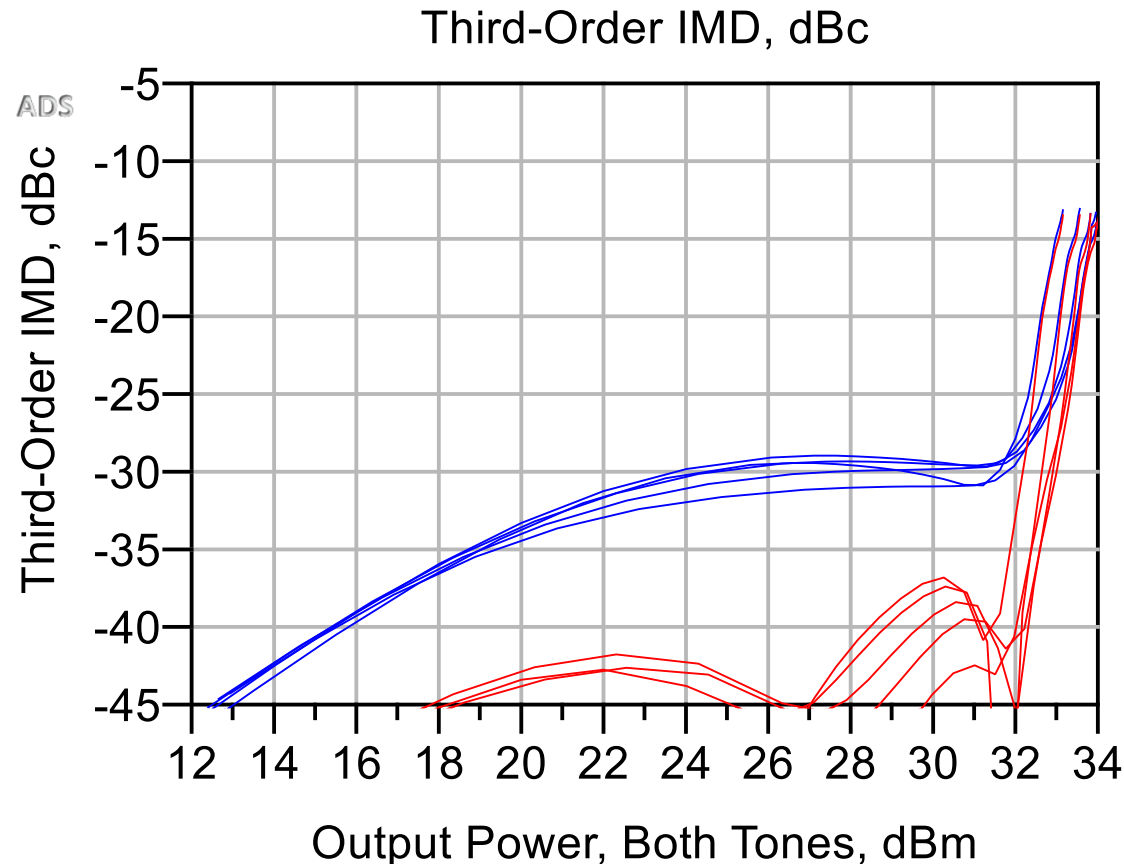
2-tone Performance @ 27GHz

- 2-tone: $27\text{GHz} - \text{fspacing}/2$, and $27\text{GHz} + \text{fspacing}/2$
- fspacing: 10M to 1GHz



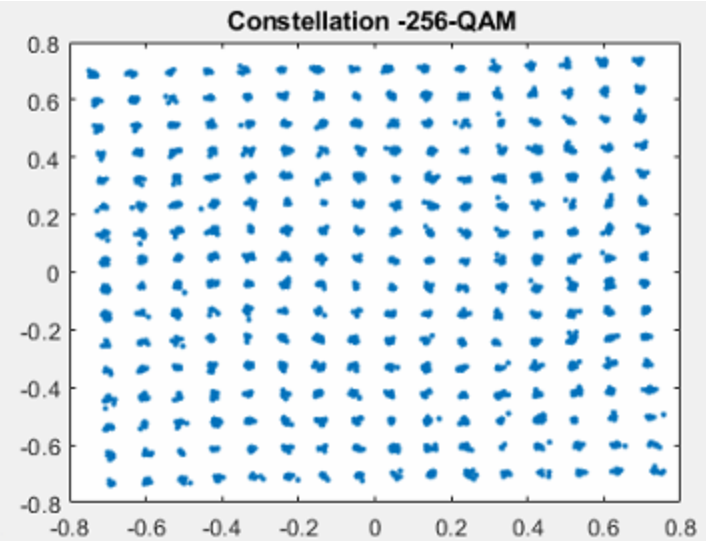
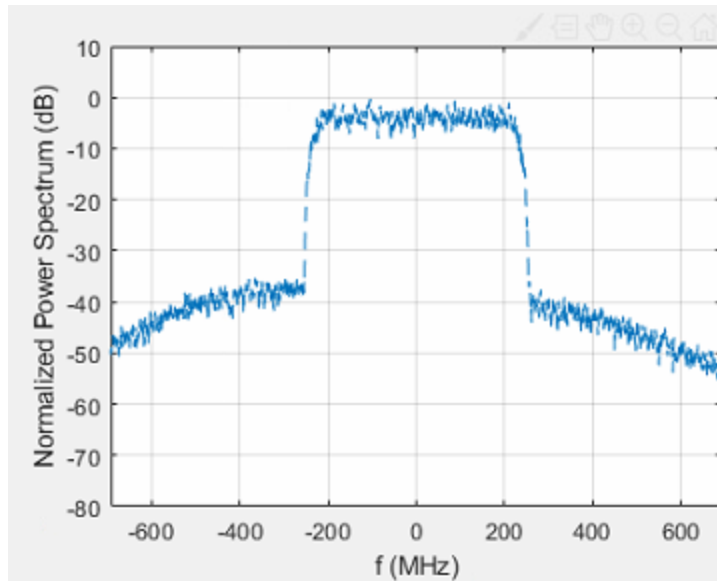
2-tone Performance over 25-29GHz

- 2-tone: $\text{RFfreq}-500\text{MHz}/2$, and $\text{RFfreq}+500\text{MHz}/2$
- RFfreq: 25G to 29GHz



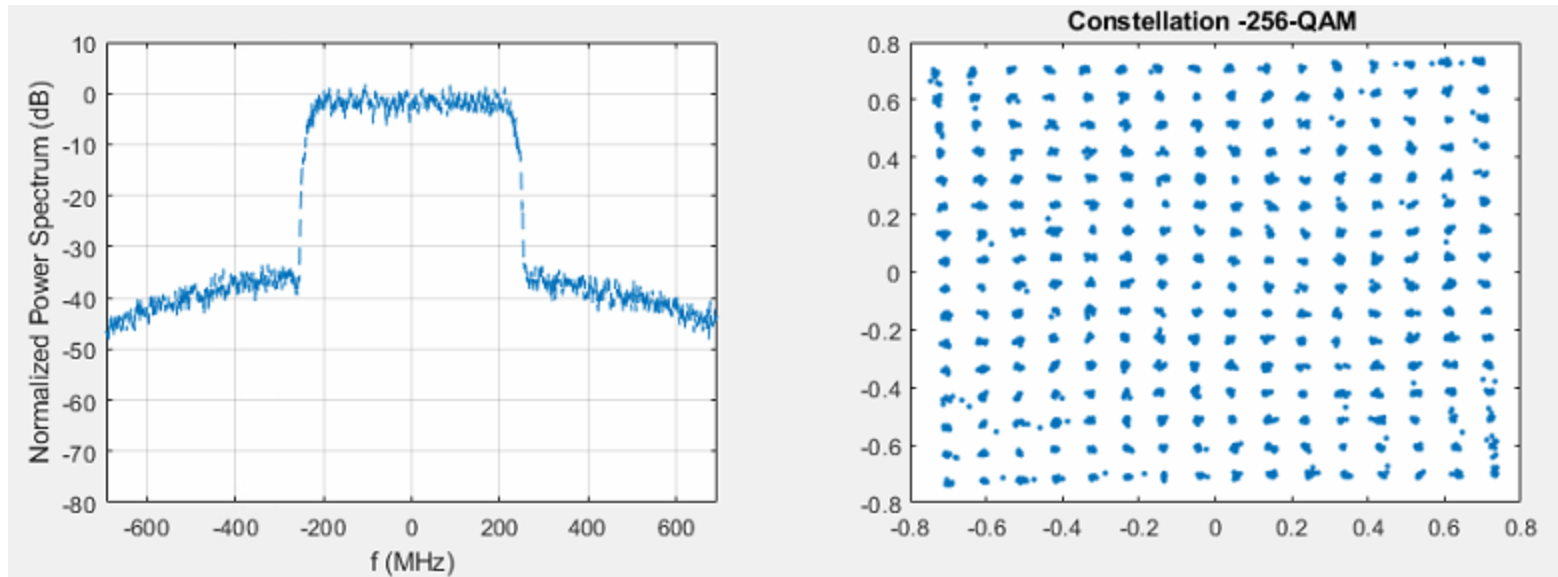
Modulated Signal

- 460MHz 256-QAM, $P_{out}=25.7\text{dBm}$
- No DPD applied



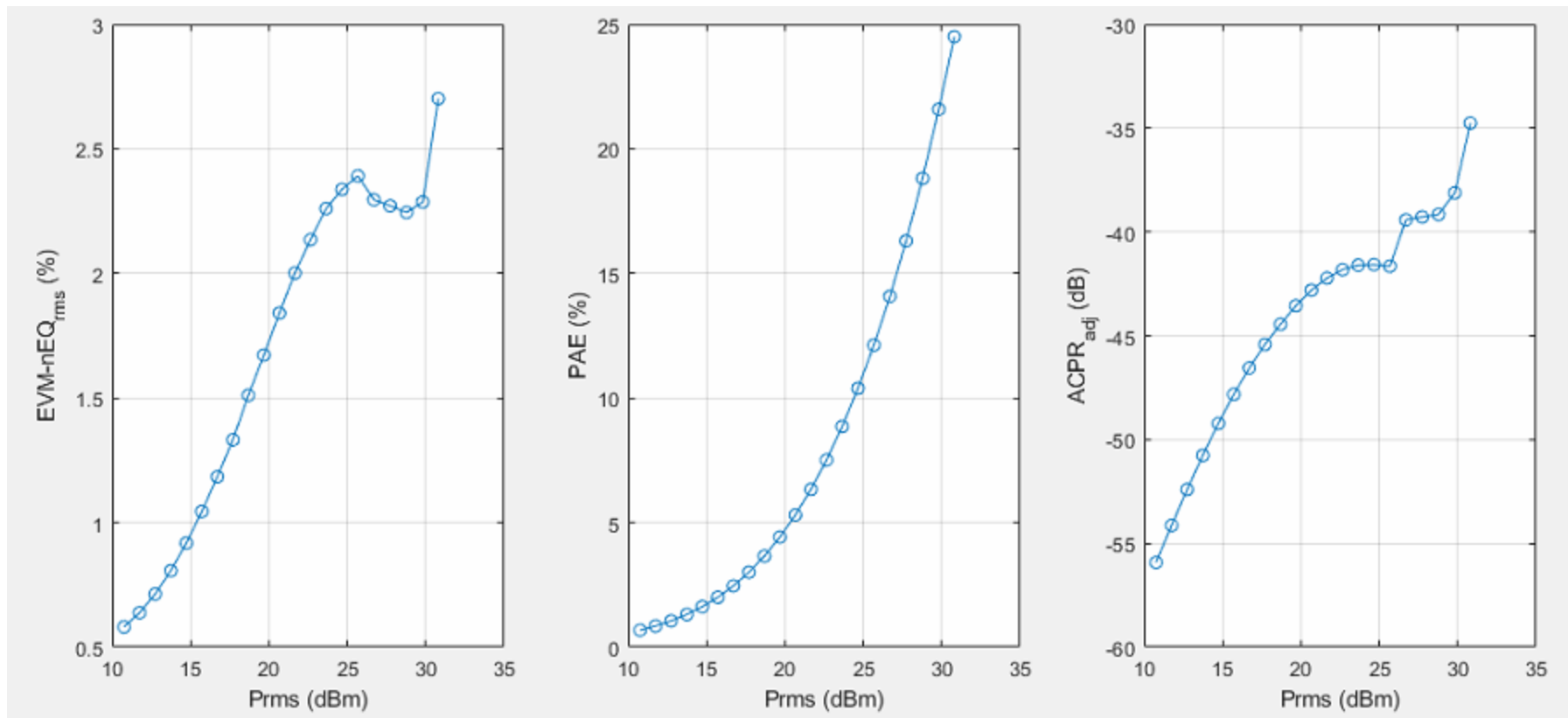
Modulated Signal

- 460MHz 256-QAM, Pout=29.8dBm
- No DPD applied



Modulated Signal

- 460MHz 256-QAM, without DPD



Summary

- Mm-wave 5G PA needs to be high power, high efficiency and high linear over large bandwidth.
- A 3-stage PA has been designed in 100nm GaN/Si process
 - 23-30GHz, covering all the world
 - 35dBm OP1dB with 40% PAE at P1dB
 - <2.5% EVM upto 30dBm Pavg

Thank you!